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ASYMMETRIC FIRMS**

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Strictness of Leniency Programs and Cartels of Asymmetric Firms*

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Abstract

This paper studies the effects of leniency programs on the behavior of firms participating in illegal cartel agreements. The main contribution of the paper is that we consider asymmetric firms. In general, firms differ in size and operate in several different markets. In our model, they form a cartel in one market only. This asymmetry results in additional costs in case of disclosure of the cartel, which are caused by an asymmetric reduction of the sales in other markets due to a negative reputation effect. This modeling framework can also be applied to the case of international cartels, where firms are subject to different punishment procedures according to the laws of their countries, or in situations where following an application for leniency firms are subject to costs other than the fine itself and where these costs depend on individual characteristics of the firm.

Moreover, following the rules of existing Leniency Programs, we analyze the effects of the strictness of the Leniency Programs, which reflects the likelihood of getting complete exemption from the fine even in case many firms self-report simultaneously. Our main results are that, first, leniency programs work better for small (less diversified) companies, in the sense that a lower rate of law enforcement is needed in order to induce self-reporting by less diversified firms. At the same time, big (more diversified) firms are less likely to start a cartel in the first place given the possibility of self-reporting in the future. Second, the more cartelized the economy, the less strict the rules of leniency programs should be.

JEL-Classification: K21, L41

Keywords: Antitrust Policy, Antitrust Law, Self-reporting, Leniency Programs

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1 Introduction

The main question we address is whether the leniency rules work (and if so – for what types of companies) given that there are other costs to admitting an infraction of competition law other than the fine. As an example of those costs we will consider reduction of sales due to the reputation effect after cartel is discovered. We define effective leniency programs in the sense that they achieve the objective of voluntary applications for leniency which in return results in the break-up of illegal cartels. Since the leniency rules only offer a reduction in the fine calculated on the basis of the affected turnover, but do not take into account the expected costs of admitting illegal behavior and ignore other costs which can potentially outweigh the fine, one can question the effect that may be expected from the leniency rules. The literature has already noted these other negative effects on the expected number of requests for leniency (see, for example, Motta and Polo (2003) or Spagnolo (200b)). We add to the literature a specific notion: companies are diversified to a certain extent and the measure of diversification is not identical for the firms. We will present a model that takes into account fines that result from a conviction by the competition authority and also other costs resulting from affected sales in markets other than those involved in illegal behavior. Earlier papers on leniency do not take this aspect into account. We will investigate how companies will react to a leniency rule given that firms are diversified to a specific extent, which is unique for each firm, and that the leniency rules do not take into account the effects on markets other than the markets on which the cartel was proven to operate.

In general, introducing a legally embedded sanctioned opportunity for whistle-blowing rewarded by fine reduction or even exemption changes the game played between the antitrust authority and the group of firms. Intuitively, this opportunity should reduce cartel stability by increasing the incentives for firms to reveal the cartel. This conclusion is well established in the literature (see, again, Motta and Polo (2003)). However, in the presence of asymmetries these incentives change. In the symmetric situation where the cartel members are identical in all respects, the firms all have identical incentives and will all apply for leniency at the same moment in time. This, however, is a very theoretical situation and, therefore, we introduce asymmetries on the basis of the measure of diversification of the firm. We will show that the effectiveness of Leniency Programs is different for different types of companies and depends crucially on the number of markets in which a firm operates relative to the number of markets covered by the cartel if one takes into account a reputation effect.

A number of earlier papers have studied effects of leniency programs in antitrust enforcement without taking into account possible asymmetries between the firms and the reputation effect. Recall Motta and Polo (2003), Spagnolo (2000), Malik (1993), or Hinloopen (2003). Malik (1993) and Kaplow and Shavell (1994) were the first to identify the potential benefits of schemes, which elicit self-reporting by violators. They conclude that self-reporting may reduce enforcement costs and improve risk-sharing, as risk-averse self-reporting individuals face a certain penalty rather than the stochastic penalty faced by non-reporting violators. The difference is that they consider individual violators rather than a group of violators. A similar paper in this field is Innes (1999), who considers environmental self-reporting schemes. Direct applications of leniency programs in antitrust policy have been studied by Motta and Polo (2003). They show that such programs might have an important role in the prosecution of cartels provided that firms can apply for leniency after an investigation has started. They conclude that, if given the possibility to apply for leniency, the firm might well decide to give up its participation in the cartel in the first place. They find also that leniency saves resources for the authority. Finally, their formal analysis shows that leniency should only be used when the antitrust authority has limited resources, so that a leniency program is not unambiguously optimal.

Another attempt to study the efficiency of leniency programs in antitrust enforcement was made in Feess and Walzl (2004). They compared leniency programs in the EU¹ and the USA². For that purpose they constructed a stage-game with two self-reporting stages, heterogeneous firms with respect to the amount of evidence provided, and ex post asymmetric information. Differences in leniency programs in the US and Europe include the fine reduction granted for first and second self-reporters, the role of the amount of evidence provided, and the impact of whether the case is already under investigation. The paper by Feess and Walzl (2004) elaborates on the role of asymmetric information to derive the optimal degree of leniency and uses these findings to compare the programs in the US and the EU.

Another line of literature we will touch upon is the literature on reputation. One of the conditions for the functioning of the reputation mechanism is that there should be information on the performance of the company, see Graafland and Smit (2004). Miles and Covin (2000) find empirical support that a reputation advantage enhances marketing and financial perfor-

¹For description of European system see Guidelines on the method of setting fines imposed (PbEG 1998) and the report of EC "Commission adopts new leniency policy for companies which give information on cartels", press release, Brussels, Feb. 13, 2002.

²For description of US system see Guidelines manual (chapter 8-Sentencing of organizations) and The twelfth annual report (DOJ 1998).

mance. Whereas they investigate the proof for an environmental reputation, we will consider the reputation of an offender of competition law. Graafland and Smit mention several ways in which reputation loss due to admitting of having been a member of a cartel may result in additional costs. A good reputation may attract highly qualified workers, it could benefit the company on the goods market and on the financial market. In this paper, we restrict ourselves to the effects of reputation on the goods market. We explicitly introduce the notion that the goods market is divided into several markets, where the reputation in one market may to some extent carry over to the reputation in another market. Of course, these effects in goods markets may directly affect the financial position of the firm, but we will not discuss these links.

Our paper contributes to this literature by studying the effectiveness of leniency programs for companies, which are not symmetric. We take into account that a conviction by a competition authority results in costs other than the fine. The additional costs we will single out are the cost associated with reduced sales in all markets the convicted cartel participant operates in. This, what we call reputation effect, depends on the size of the firms. The effectiveness of a leniency program largely depends on markets outside the market corrupted by the cartel agreement.

The structure of the paper is as follows. We will start in section 2 by giving a qualitative description of the problem followed by a summary of the system of leniency rules adopted by the Dutch national competition authority, the Nederlandse Mededingingsautoriteit (NMa). Section 3 provides formal description of the model. In section 4, we solve the model and find subgame perfect equilibrium of the game. Section 5 outlines the optimal enforcement strategies of antitrust authority and strategies that allow to implement the no collusion outcome. Finally, section 6 concludes the analysis.

2 Outline of the Model

2.1 Qualitative Analysis

The model consists of three groups of actors - firms, consumers, and the competition authority. We assume that companies are asymmetric in the sense that they are diversified to different extents. We intend this to imply that firms operate in several distinct relevant markets. The competition authority has the power to scrutinize all markets. However, practical constraints (resources) imply that it cannot investigate all markets to the same degree. The general public only gets proof on the existence of a cartel when the findings of the competition authority result in a formal report. Enterprises only have knowledge about the cartels in which they are

involved. For the markets in which they are not present they have no information advantage over the general public.

We assume that both the public and enterprises react to cartel findings in that they reduce purchases from the enterprises that are fined. The intuitive explanation for this behavior is that buyers have an instinctive desire to punish the cartel members and reduce purchases from the offenders. The consumers thus apply a tit-for-tat strategy; as soon as they discover that they have been deceived by producers they reduce their purchases from the producers involved. This reduction in sales can be modelled as a factor $R \in (0, 1)$ (for reduction) of the sales of the cartel members that were part of the illegal agreement. Notice that if all producers are involved, the consumers have a desire to reduce consumption, but they are not able to find alternative suppliers. In this situation, we assume that the buyers will temporarily withhold purchases whenever possible³.

Another reasoning that is based more on rational behavior rather than introducing reactions not normally associated with the “homo economicus” but reaching the same conclusion involves uncertainty. Assuming that consumers (a) have a preference for goods with a higher quality ($dU/dQual > 0$) but (b) cannot perfectly observe the quality of a good even after purchasing the good (because reliability and durability can only be estimated after some time), one can argue that consumers take the relative prices as an indication of relative quality. Profit margins are implicitly considered identical and all firms all equally efficient resulting in a direct relation between production costs and product quality. The consumers then choose the product with the optimal price/quality ratio given the budget constraints. After the discovery of a cartel by the competition authority, buyers know that they have paid a mark-up over and above normal profit margins to the enterprises that are involved in the cartel, implying that the cost component (related to expected quality) must have been lower than that of non-cartel competitors. Thus, the message to buyers is that the quality of the product of the cartel-members must have been lower than expected. Since they have no reason to assume that other, competing enterprises in the same market have applied the same mark-up, these products gain a quality reputation and buyers redress their buying patterns optimizing the price/quality level incorporating the new

³An indication of this behavior is clear in the building sector in the Netherlands. Following the discovery and publication of an extensive documentation on widespread illegal transactions by hundreds of construction companies, there have been a significant reduction in sales. The sector considers this discovery as one of the causes of the economic downturn of the sector. The publication of this case was made by a specific parliamentary inquiry board, whereas, in general only the information published by the Competition authority will be available.

However, this economic downturn of the sector can possibly also be attributed to the business circle effect.

information.

The crucial observation to make here is that consumers do not fine-tune their retaliatory actions to the relevant market(s) affected by the cartel, but rather reduce expenditure on all the products and services produced by firms that were convicted for participating in the cartel. Most of the public, and perhaps to some extent even private enterprises, are unable to distinguish between organizational divisions within the offending companies and the application of very specific defined relevant product and geographic markets used by the competition authorities. Thus the subtleties of the fact that an operational unit of a company is named as the participant of an illegal cartel in a specific relevant market are lost and the company is considered to have participated in a cartel increasing the price of (all) its products. This implies that the reduction R is applied to the sales of all products of the company (not only on the markets involved).

We consider the assumption that all sales are reduced the very plausible. In markets for final goods, this holds especially when sales on many independent relevant markets are made under a common brand or company name and consumers simply associate the brand name with the cartel. In markets for immediate goods, where the buyers are professionals, there are two effects which may cancel out so that the level of reduction, R , may be identical to that associated with final consumers. The first effect is that the professional buyers may be better able to make a distinction between the part of the seller's organization that was part of the cartel and the part of the organization that was not involved, thus resulting in an overall lower R . The second effect is that the professional buyers may be better able to determine the origin of products even when these are marketed using separate brand names, thus resulting in an overall higher level of R . For simplicity, we will not make a distinction between markets for final consumers and markets for intermediate consumers and therefore use a single value for R .

With enterprises that have issued publicly held and traded shares, one additional source of loss of wealth is that the expectation of lower sales immediately results in a lower valuation of the shares. If consumers act in the way that we model – i.e. they reduce purchases from the companies involved in all markets where these enterprises operate – the loss in share value may well be more significant than one would expect on the basis of the reduction in sales in the markets where the cartel has been proven to exist. Indeed there are such empirical indications that support the plausibility of the existence of a reduction R on all sales rather than on affected sales only. Soppe (2000), considering the effects on companies after discovery of participation in a cartel, concludes that the loss in investor returns is normally much bigger than what would be expected on the basis of expected fines and compensations. Archer and Wesolowsky (1996)

find that owners of durable goods do not seem to tolerate more than one incident without consequences for not only product loyalty but also manufacturer loyalty. This could point to the existence of expectation of reduction of sales in other than the affected markets.

2.2 The Leniency Policy of the NMa

In the EC competition law, a leniency policy was introduced in 1996. The Dutch national competition authority (NMa) adopted leniency rules on July 2, 2002. The current version we will discuss is the Richtsnoeren Clementietoezegging, last amended on April 28, 2004. The text on the leniency rules is numbered in the margin, and we will refer to the numbers in the margin for ease of reference.

The purpose of the leniency rules is to give the NMa a choice of whether to impose a fine or not when it discovers and proves breach of either article 6 Mw or article 81 EC (2). The objective of leniency is to gain information on cartels and to make discovery, punishment and termination of cartels more effective (1). Thus, the NMa can offer reduction of fines to members of a cartel that wish to terminate their involvement in behavior that is illegal under cartel legislation. The leniency rules make a distinction between several situations. The biggest reductions are obtained when a cartel member informs the NMa of a cartel before the NMa has started a formal investigation. The first cartel member to approach the NMa with sufficient information to start an investigation obtains 100% immunity for resulting fines unless this company forced other companies to participate in the cartel or the company does not fully cooperate during the investigation (5). Who is first depends on the exact time the companies first contacted a leniency officer (14). The first cartel member to help the NMa with additional information after starting an investigation of this cartel will receive a reduction of between 50 and 100% of the fine given that this company has not forced other companies to participate in the cartel and that the company cooperates during the investigation. Additional information is defined as information that the NMa did not have before and without which the case cannot be proven (9). Companies that were either not the first to approach the NMa with additional information with respect to a specific cartel or that were the first to contact the NMa with additional information but that had forced other companies to participate in the cartel can obtain fine reduction ranging from 10 to 50% (7). In addition, the companies providing additional information do receive 100% immunity for information resulting in an increase in the fine on which the reduction is applied (10) (e.g. because the cartel was in operation longer than assumed on the basis of the investigation of the NMa or the information of the informer that resulted in the start of the

investigation).

3 The Model (Formal Analysis)

We consider a group of firms, which may form a cartel, taking into account the enforcement activity of the antitrust authority. The antitrust authority commits to a certain enforcement policy, which uses leniency programs. Leniency programs grant either complete or partial reduction of fines to the firms, which reveal the existence of a cartel to the antitrust authority. The main innovation of this model, compared to the earlier papers on leniency by Motta and Polo (1999) and (2003) or Feess and Walzl (2003), is that we consider asymmetric firms that have different size and operate in several different markets, but form a cartel only in one market. This gives rise to additional costs in case of disclosure of cartel that are caused by a reduction of the sales in other markets due to a negative reputation effect. This effect is asymmetric: firm 1 bears additional costs of Rh_1 , while firm 2 suffers additional costs of Rh_2 . Here h_1 and h_2 are the total sales in other markets, in which the relevant company does not form a cartel. The second innovation of the model is that the leniency policy of antitrust authority is not only limited to the option of fine reduction for self-reporting firm, but also takes into account possibility of different treatment of the first and second reporter that is imbedded in the current leniency rules of many competition authorities worldwide.

First, we describe the policy choices of the antitrust authority. Second, we specify the firms' strategies. And, finally, we describe the timing of the game.

Enforcement policy: The main goal of the antitrust authority is to prevent cartel formation in the first place. However, if the cartel has already been formed, the antitrust authority aims to discover it at the lowest possible cost. Following Becker (1968), we distinguish two main parameters of enforcement policy: penalty and probability of detection. Hence, the antitrust policy in the presence of leniency programs can be described by the following three parameters.

- The full fines $F \in [0, F^{\max}]$ for firms that are proved guilty and that have not cooperated with the antitrust authority, where F^{\max} reflects the upper bound for the fine that is exogenously given by the law⁴. Following the Becker's argument, in this set-up, the fixed fine F will generally be set at F^{\max} .

- The reduced fines $f \in [0, F)$ specified by leniency programs. In particular, if only one of

⁴According to the NMa, the maximum fine depends on the turnover in all markets, not only the market where the illegal agreement applied to.

the firms reports the cartel, then this firm pays no fine, while the other firm will pay the normal fine, F . Moreover, we consider the set-up in which all the firms that cooperate can be granted reduced fines f . However, the amount of reduction depends on the circumstances, especially the order of self-reporting and the "value" of additional information. Applying the rules of current Dutch leniency practices discussed in section 6.2⁵, the possibility of simultaneous self-reporting by the firms should be ruled out. However, the model, described in this paper, is richer and can also predict in the situation where firms self-report simultaneously. To simplify the analysis, we consider a two-firms' game. The first firm to self-report gets complete exemption from the fine, while the second pays the reduced fine, $f = \frac{1}{2}F$.⁶ This set-up describes the most strict adherence to the Leniency rules. However, we will also consider an alternative set-up, where the antitrust authority is less strict and grants partial immunity to both firms in case they self-report almost at the same time. This possibility will be captured by an additional (non-traditional) instrument of antitrust authority, which we call "strictness" of leniency rules, and which is denoted by α . This parameter reflects the estimated probability that the firm, which self-report almost simultaneously with its rival, gets zero fine.

- The probability of law enforcement by the antitrust authority equals $p \in (0, 1]$. This variable can be thought as an instantaneous probability that the firm is checked by antitrust authority and found guilty. Contrary to Motta and Polo (2003), we assume that whenever the antitrust authority checks the guilty firm, the violation is successfully discovered. Moreover, we assume that p is determined by an exogenous budget of the antitrust authority financed by the government that can be used to promote enforcement, so that p reflects the costs of efforts of antitrust authority put into law enforcement activities.

Firms' strategies: We analyze two different **collusive strategy profiles** of the firms (Enter Cartel and Self-report; and Enter Cartel and Not Self-report) and one **competitive strategy profile** (Not Enter the Cartel in the first place).

First, we consider the strategy Enter Cartel and Self-report (E, S) . The firms decide to enter a cartel agreement. This may give them per period profits π_m if the cartel is stable. At the next stage of the game one or both firms choose to report the existence of the cartel to

⁵Richtsnoeren Clementietoezegging, last amended on April 28, 2004.

⁶These rules are roughly consistent with partial immunity clauses that often apply if more than one cartel member reports. Moreover, Apestegua, Dufwenberg and Selten (2003) use a similar mechanism to design one of the treatments in their experimental paper, which studies the effects of leniency on the stability of cartel. Feess and Walzl (2003) consider partial reduction of fines for both firms in case of simultaneous self-reporting.

the authority. This allows them to obtain a reduced fine. However, they lose not only extra profits from cartel formation, but also a fraction of the sales in other markets, since information about cartel becomes publicly available. The second collusive strategy is Enter Cartel and Not Self-report (E, NS). In this case the payoff is determined as an expectation of the monopoly gains, π_m (if cartel is not found), and competitive profits, π_n , less the fine and losses due to the reputation effect (if violation is discovered by antitrust authority).

The competitive strategy profile is "Not Enter the Cartel in the first place": ($NE, -$), which implies that the two stage game is reduced to one stage. In this case both firms obtain competitive profits π_n forever. Note that $0 \leq \pi_n < \pi_m$.

Timing of the game:

The two asymmetric firms play the two stage game without knowing the action of the rival. At time $t = 0$ the antitrust authority sets parameters of enforcement policy: F and p . Here we assume that leniency program is not yet into existence at time $t = 0$ and, hence, no reduction of fine is possible in case the firm cooperates with the antitrust authority. Consequently, self-reporting is not an option at this stage. This set up resembles the policy of, for example, Dutch Competition Authority (NMa) before the year 2001, when the leniency programs were introduced in The Netherlands⁷.

Next, at time $t = 1$ "the cartel formation subgame" is played. At $t = 1$ both firms decide whether to participate in the cartel or stay out and realize the per-period associated payoff, respectively π_m and π_n . If both firms agree to participate, the cartel is formed and the game continues into second stage. If at least one of the firms decides to stay out, the game stops and both firms obtain competitive profits, π_n , forever. We assume that the existence of a collusive outcome in the industry cannot be observed by the antitrust authority until it starts an investigation in this market.

Further, at time $t = 2$ (an analogy of the year 2001 in The Netherlands) the antitrust authority introduces leniency programs, which allow firms to be exempted from the fine in case

⁷When leniency programs are already present, then (E,S) equilibrium is dominated by Not Entering equilibrium. In that case the game played is not a two stage game anymore but can be considered as a simultaneous move game and there are no additional cartel profits realized in the first stage. This implies that in the situations where the structure of the penalty scheme and leniency programs are both introduced in the beginning of the game, as it is at the moment in most developed economies, the solution of the game would follow the same lines as described in section 4 with one simplification that the strategy (E,S) will not be played in equilibrium any more (for any possible parameter values), since it's strictly dominated by the strategy not to enter the cartel in the first place.

of self-reporting. Now those firms, who already formed a cartel, have the choice either to keep it secret or report it to the antitrust authority. Hence, at $t = 2$ "the revelation subgame" is played, where both firms simultaneously decide whether to report the existence of the cartel to the authority or not. If at least one of them does so, cartel formation stops and both firms obtain π_n . If no firm reveals, the antitrust authority is able to prove them guilty and punish with probability $p \in (0, 1]$ in any subsequent period. We assume here again, differently from Motta and Polo (1999), that a firm proved guilty does not collude any more, so after being punished firms do not go back to collusion, while in case the cartel has not been revealed or discovered, firms sustain the collusive strategy for at least one more period and obtain monopoly profits, π_m .

The antitrust authority does not take an active part in the game. It only sets policy parameters, F , f , p , α , and the rules of leniency programs. As said before, the strictness of the leniency rules is modelled through parameter α . A "strict" antitrust authority would give complete exemption from the fine only to the self-reporting firm, which is literally the first to self-report. In this case parameter α is close to zero and the firm that cooperates will almost surely get only partial exemption. Hence, it pays the reduced fine, $f = \frac{1}{2}F$. A "mild" antitrust authority can give complete exemption from the fine to all the firms that cooperated. In this case the parameter α is equal to 1 and every cooperating firm gets zero fine. It speaks for itself that in our model α is only relevant when both firms self-report at the same stage of the game.

It should also be mentioned that under a regular antitrust policy without a leniency program, collusion can be sustained only when the short run gain from an unilateral deviation from collusive agreement by undercutting in prices is smaller than the expected loss triggered by the deviation. This loss follows from the fact that cartel profits, π_m , will be replaced by competitive profits, π_n . Hence, collusion under a regular antitrust policy (i.e. when leniency is not available, and only rate of law enforcement and fine are instruments of competition authority) takes place only when the following inequality is satisfied for each firm

$$\frac{\pi_m - p(F + Rh_i)}{1 - \delta} > 2\pi_m - p(F + Rh_i) + \frac{\delta\pi_n}{1 - \delta} \quad \text{for } i = 1, 2. \quad (1)$$

Where $2\pi_m$ reflects the extra profits from undercutting, since we assume there are only two firms in the market. This inequality implies that collusion can arise only when the discount factor is large enough, namely, $\delta \geq \frac{\pi_m}{2\pi_m - \pi_n - pF - pRh_i}$ for $i = 1, 2$. This condition states that the discount factor required to induce collusion is smaller if either the difference between monopoly profit and competitive profit (the gains of cartel) increases and/or the expected fine

(the expected costs following discovery of the cartel) decreases. If this condition is not met, it is more attractive for either of the firms to deviate from the collusive strategy, and obtain monopoly profits for one period and then compete for the rest of the game. For the further analysis we restrict our attention to the case where this condition is met for both firms, which implies that in the absence of leniency programs, the equilibrium state is collusion. Hence, inequality (1) represents a necessary condition for the second stage of the game ("revelation subgame" played at $t = 2$) to be reached. Another important restriction on the discount factor is $\delta \geq \frac{\pi_m}{2\pi_m - \pi_n}$, which implies that in the absence of the antitrust policy, collusion would arise in equilibrium⁸. Note that in this case the second stage of the game ("revelation subgame") is also automatically reached, since it is implied by $\delta \geq \frac{\pi_m}{2\pi_m - \pi_n - pF - pRh_i}$.

It should be stressed that for any $t > 2$, the decisions of both players do not change and payoffs obtained at $t = 2$ will be discounted into the future. This is due to the fact that the penalty is fixed and, hence, the environment does not change.

We summarize the above description of the game as follows:

Stage 0: Antitrust authority announces parameters of the penalty scheme, p and F .

Stage 1: Firms decide whether to be in a cartel or not (once and for all decision).

Stage 2a: Antitrust authority introduces leniency program.

Stage 2b: Firms decide whether to self-report or not (once and for all decision). If no self-reporting by both firms is chosen then repeated game between authority and firm, where authority can discover violation with probability p in each period, is played till infinity.

The discount factor is denoted by $\delta = \frac{1}{1+r}$, where r is an interest rate. The game tree and players' payoffs are described in Figure 1.

We now proceed to establish the subgame perfect equilibria of the two stage game, which is described in Figure 1, played among firms once the policy parameters are set.

⁸In the absence of any antitrust enforcement, i.e. when neither fines nor rate of law enforcement can be used, collusion can be sustained only when the short run gain from an unilateral deviation from collusive agreement by undercutting in prices together with competitive profits thereafter is smaller than the payoff from sustaining collusive strategy forever: $\frac{\pi_m}{1-\delta} > 2\pi_m + \frac{\delta\pi_n}{1-\delta}$ for $i = 1, 2$.

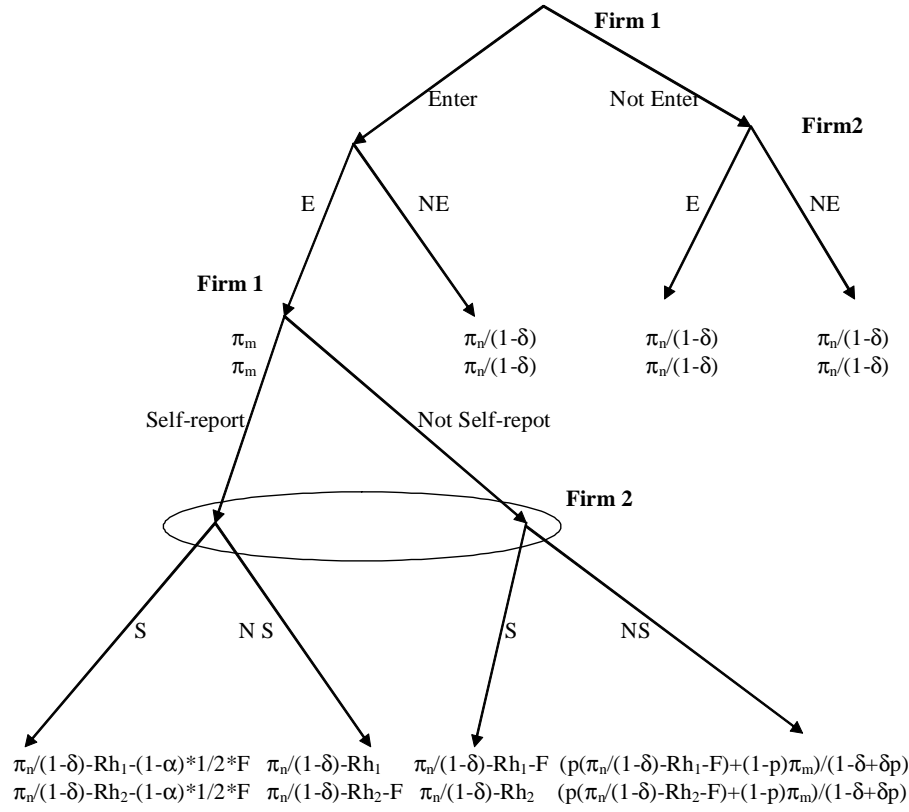


Figure 1: Game tree and players' payoffs.

4 Solution of the Game

4.1 Solution of "Revelation Subgame"

To find the subgame perfect equilibria of the game, consider first the "revelation subgame", which is played in stage 2. In case of simultaneous self-reporting, a firm i gets a payoff of $\frac{\pi_n}{1-\delta} - Rh_i - \frac{(1-\alpha)}{2}F$. This expression reflects the rules of current sentencing guidelines that the first firm to self-report gets complete exemption from the fine, while the second pays the reduced fine, $f = \frac{1}{2}F$. Given that the other firm self-reports at approximately the same time, the probability to be the first to report and get zero fine is α . However, there is also a chance $(1 - \alpha)$ that another firm is the leader in the "race to the court". If a firm i does not self-report but the other firm does, then this firm receives a payoff of $\frac{\pi_n}{1-\delta} - Rh_i - F$, while the other firm is granted complete leniency and obtains $\frac{\pi_n}{1-\delta} - Rh_j$. Recall that there is still a negative reputation effect, because information about the cartel becomes public. Finally, if no firm self-

reports, each firm receives an expected payoff $\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p}$ ⁹. The normal form of the simultaneous move "revelation subgame" is given in the Table 6.1 below.

firm 1 \ firm 2	Self-report	Not Self-report
Self-report	$\frac{\pi_n}{1-\delta} - Rh_1 - \frac{(1-\alpha)}{2}F$, $\frac{\pi_n}{1-\delta} - Rh_2 - \frac{(1-\alpha)}{2}F$	$\frac{\pi_n}{1-\delta} - Rh_1$, $\frac{\pi_n}{1-\delta} - Rh_2 - F$
Not Self-report	$\frac{\pi_n}{1-\delta} - Rh_1 - F$, $\frac{\pi_n}{1-\delta} - Rh_2$	$\frac{p(\frac{\pi_n}{1-\delta}-Rh_1-F)+(1-p)\pi_m}{1-\delta+\delta p}$, $\frac{p(\frac{\pi_n}{1-\delta}-Rh_2-F)+(1-p)\pi_m}{1-\delta+\delta p}$

Table 6.1: The normal form of the simultaneous move "revelation subgame".

It is easily verified that the tuple (*Self-report*, *Self-report*), that we denote as (S, S), in which all firms choose to cooperate with Antitrust Authority obtaining a reduction of fines, is always a Nash Equilibrium. The tuple (*Not Self-report*, *Not Self-report*), or (N, N), is an equilibrium if the following condition holds $\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p} \geq \frac{\pi_n}{1-\delta} - Rh_i$, $i = 1, 2$. Note also, that the (N, N) would also be Pareto dominant or payoff dominant equilibrium if the following inequality is satisfied $\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p} \geq \frac{\pi_n}{1-\delta} - Rh_i - \frac{(1-\alpha)}{2}F$.¹⁰ This implies that Self-Reporting can be sustained in equilibrium if the following condition holds:

$$p > \frac{\pi_m - \pi_n + Rh_i(1 - \delta) + \frac{(1-\delta)(1-\alpha)}{2}F}{\pi_m - \pi_n + Rh_i(1 - \delta) + (1 - \frac{\delta(1-\alpha)}{2})F} = p^*(F, h_i, \alpha) \text{ for } i = 1, 2 \quad (2)$$

It is easily verified that for player i the payoff from self-reporting is strictly greater than the payoff from keeping the cartel secret, only when $p > p^*(F, h_i, \alpha)$ ¹¹. Only if $\frac{\pi_n}{1-\delta} - Rh_1 - \frac{(1-\alpha)}{2}F >$

⁹The complete derivation of this expression is quite easy to show using the recursive formula. Value of the strategy (*Enter* and *Not self-report*) can be written as $V = (1 - p)[\pi_m + \delta V] + p[(\pi_n - Rh_i - F) + \frac{\pi_n \delta}{1-\delta}]$. Here, with probability $(1 - p)$ firms can continue collusion in the next period and with probability p cartel will be discovered in the next period which causes fine and losses due to the reputation effect. Now, solving for V , we obtain that $V = \frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p}$.

¹⁰The notion of Pareto-dominant equilibrium is well established in the literature (see, for example, Fudenberg and Tirole (1991) pp. 20-22). Following their arguments, players will coordinate on the Pareto-dominant equilibrium if they are able to talk to one another before the game is played and agree to play highest payoff equilibrium in case of multiple Nash Equilibria. And, since firms are perfectly rational payoff maximizing agents, there is no reason for them to deviate from this agreement later on.

¹¹We assume here that (S, S), (S, N), or (N, S), which lead to self-reporting outcome in the second stage of the game, can only be chosen when both inequalities $\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p} < \frac{\pi_n}{1-\delta} - Rh_i$ and $\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p} < \frac{\pi_n}{1-\delta} - Rh_1 - \frac{(1-\alpha)}{2}F$ are satisfied. This implies that p must be greater than $p^*(F, h_i, \alpha)$. This assumption is equivalent to employing pareto-dominance criterion or, in other words, choosing an outcome on the pareto frontier.

$\frac{p(\frac{\pi_n}{1-\delta}-Rh_i-F)+(1-p)\pi_m}{1-\delta+\delta p}$ for $i = 1, 2$, then (S, S) equilibrium is pareto-dominant in the "revelation subgame" and, hence, (Enter and Self-report) outcome will be preferred by both firms over (Enter and Not Self-report) outcome in the two stage game. Therefore, following Pareto-dominance criterion, firms self-report in the second stage only if $p > p^*(F, h_i, \alpha)$. This gives us the first incentive compatibility constraint. We represent it in Figure 2 by the line p^* , which plots $\alpha(p)$ as a convex decreasing function of p in the $(p, \alpha) - plane$.

In addition, comparative statics of the behavior of $p^*(F, h_i, \alpha)$ with respect to the main parameters of the model shows that

$$\frac{\partial p^*(F, h_i, \alpha)}{\partial h_i} > 0, \quad \frac{\partial p^*(F, h_i, \alpha)}{\partial F} < 0, \quad \frac{\partial p^*(F, h_i, \alpha)}{\partial \alpha} < 0 \quad (3)$$

The first inequality is a result of incorporating the level of diversification (or asymmetries) of the firms. The more diversified the firm is (strictly speaking, the higher the turnover from markets not cartelized compared to total turnover) the bigger the incentives for the firm to abstain from self-reporting. In other words, this implies that the bigger the size of the firm (or the greater the amount of "honest" sales) in other markets, the higher the incentives for this firm to keep the cartel secret, since a bigger threshold probability $p^*(F, h_i, \alpha)$ implies that greater efforts from antitrust authority, in terms of increasing the rate of law enforcement, are needed in order to induce the self-reporting by this firm. The second inequality in (3) reflects the usual trade-off between the probability and severity of punishment extensively discussed in Becker (1968) and in Garoupa (1997) and (2001). The third inequality in (3) implies that the uncertainty of the firms about getting the first price (or, in other words, strictness of the rules for leniency¹², which can grant the complete exemption from the fine only to one firm) actually reduces the incentives for both types of the firms to self-report.

4.2 Solution of "Cartel Formation Subgame"

Now we move on to the decision taken by the firms in stage 1 of the game. For each firm, we have to calculate the discounted sum of profits if firms form a cartel and compare it with the discounted sum of profits in case the cartel is not formed. This comparison has to be done for both cases, either when firms decide to self-report in the second stage of the game, and when they prefer to continue the cartel.

¹²We refer here to the current Leniency rules of NMa. This rules correspond to low α in our setting, which means that there is very high uncertainty for the firms about getting the first prize. From the third inequality in (3) it follows that in this case the threshold probability $p^*(F, h_i, \alpha)$ is maximal and, hence, the incentives for the firms to self-report are reduced.

First, we consider the betrayal scenario where both firms choose the strategy Enter Cartel and Self-report, which we denote (E, S) . According to analysis of previous section this strategy can arise when $p > p^*(F, h_i, \alpha)$ for $i = 1$ or $i = 2$, or both. In case both firms self-report in the second stage of the game, the expected payoff for each firm includes the collusive profits obtained at $t = 1$ plus the expected payoff from simultaneous self-reporting at $t = 2$, derived in the previous section, and is given by the following expression¹³:

$$V_{E,S} = \frac{\pi_m}{\delta} + \frac{\pi_n}{1-\delta} - Rh_i - \frac{(1-\alpha)}{2}F \quad (4)$$

However, when no agreement about cartel formation is reached the discounted payoffs for both firms, evaluated at $t = 2$, are given by expression $V_{NE,-} = \frac{\pi_n}{\delta(1-\delta)}$.

Collusion and self-report will arise if $V_{ES} > V_{NE}$, that is, if the following condition is satisfied:

$$\frac{\pi_m - \pi_n}{\delta} - Rh_i - \frac{(1-\alpha)}{2}F > 0. \quad (5)$$

This implies that the value of the parameter α that is necessary in order to ensure that the cartel is not formed, should satisfy:

$$\alpha < \alpha^*(h_i, F) = \frac{2Rh_i\delta + F\delta - 2(\pi_m - \pi_n)}{\delta F} \quad (6)$$

This expression provides the second incentive compatibility constraint, which is represented in Figure 2 by the horizontal line α^* . Note, that three considerably different solutions can arise depending on the parameter values of the model. When $2Rh_i\delta + F\delta > 2(\pi_m - \pi_n) > 2Rh_i\delta$, we obtain from (6) that $0 < \alpha^*(h_i, F) < 1$ and then the graph in the right part of Figure 2 applies. When $2(\pi_m - \pi_n) < 2Rh_i\delta$ we obtain from (6) that $\alpha^*(h_i, F) > 1$ and then the incentive compatibility constraints and SPNEa of the game are represented by the graph in the left part of Figure 2. The third possibility is when $2Rh_i\delta + F\delta \leq 2(\pi_m - \pi_n)$, so that $\alpha^*(h_i, F) \leq 0$. In this case equilibrium with no collusion will be lost. The competitive outcome will not arise in equilibrium for any parameter values. The intuition behind this result refers to the fact that when the losses to the firm both due to the fine imposed and due to the reduction of sales caused by the reputation effect are not high enough, the leniency programs can, actually, have a perverse effect. Too low fines can lead to an outcome where all the firms will participate in a cartel agreement and then depending on the size of relative gains and losses reveal it or keep it secret.

¹³To simplify the calculations we evaluate all the payoffs at time $t = 2$. So that, we discount payoffs obtained at $t = 1$ into second period with the factor $(1+r) = \frac{1}{\delta}$, and payoffs obtained in periods $t > 2$ into second period with discount factor $\frac{1}{(1+r)^{t-2}} = \delta^{t-2}$.

The expression (5) implies that the higher the h_i , the less likely this inequality will hold. Hence a bigger firm, which operates in many markets, would be less willing to enter the cartel agreement in the first place. In other words, for bigger firms the strategy to form a cartel and then self-report is more likely to be dominated by a strategy of not entering the cartel agreement in the first stage of the game, than for a smaller firm, for which h_i is low.

We can also notice that the decision of both firms when they choose between the strategy Enter Cartel and Self-report or Not Enter the cartel at all does not depend on the value of p (rate of law enforcement). However, it does depend on other parameters of the model, such as F and α . In particular, a higher fine reduces the value of the strategy Enter Cartel and Self-report, and increases the incentives for the firms to stay out of the cartel. At the same time the lower the parameter α , which reflects the perceived probability for the firm to be the first to report, or the higher the uncertainty about getting the first prize, the greater the incentives for the firms to stay out of the cartel.

Looking at the first and second incentive compatibility constraint simultaneously¹⁴, we obtain that for all $\alpha < \alpha^*(h_i, F)$ firms choose not to enter the cartel in the first place, and for all $\alpha > \alpha^*(h_i, F)$ and $p > p^*(F, h_i, \alpha)$ firms prefer to collude and then self-report in the second stage of the game. This proves the following lemma.

Lemma 1 *For given policy parameters (F, f, p, α) , a subgame perfect equilibrium in which firms enter the cartel and self-report exists if $p > p^*(F, h_i, \alpha)$ and $\alpha > \alpha^*(h_i, F)$.*

The outcome of this lemma is depicted in the right part of Figure 2 by the shaded trapezium. In the left part of Figure 2 this equilibrium is absent, since for more diversified firms value of α^* is likely to be greater than 1. The right part of Figure 2 shows that for $p > p^*$ and $\alpha > \alpha^*$ both firms decide to enter the cartel in the first stage and then, because of the high probability of conviction and the fact that rules of leniency programs are not too strict, so that almost surely every cooperating firm gets complete immunity from fine, firms choose to reveal the violation.

Next, we look at the second possible outcome of the stage 2 of the game, where both firms choose *Not to Self-report*. This outcome arises under condition $p \leq p^*(F, h_i, \alpha)$ for both $i = 1, 2$. In this case, firms anticipate that neither of them will reveal any information. The expected payoff from playing this strategy for each firm includes the collusive profits obtained at $t = 1$ plus the expected payoff from non-cooperation with antitrust authority at $t = 2$ and

¹⁴See the right part of Figure 4, which reflects the case where the critical value of α^* is less than one.

is given by the following expression¹⁵:

$$V_{E,N} = \frac{\pi_m}{\delta} + \frac{p(\frac{\pi_n}{1-\delta} - Rh_i - F) + (1-p)\pi_m}{1-\delta+\delta p}$$

Again, when no agreement about cartel formation is reached, the discounted payoffs for both firms evaluated at $t = 2$ are given by expression $V_{NE,-} = \frac{\pi_n}{\delta(1-\delta)}$.

Collusion can arise if $V_{E,N} > V_{NE,-}$, that is if the following condition is satisfied:

$$p \leq \frac{\pi_m - \pi_n}{\delta(F + Rh_i)} = p^{**}(F, h_i) \quad \text{for } i = 1, 2. \quad (7)$$

Comparative statics of the expression (7) with respect to the main parameters of the model shows that

$$\frac{\partial p^{**}(F, h_i)}{\partial h_i} < 0, \quad \frac{\partial p^{**}(F, h_i)}{\partial F} < 0. \quad (8)$$

The first inequality implies that the bigger the size of the firm (or the greater the amount of "honest" sales) in other markets, the smaller the threshold probability $p^{**}(F, h_i)$, and, hence, the easier for antitrust authority to prevent the firm from entering the cartel agreement in the first stage of the game. The second inequality, as above, reflects the usual trade-off between the probability of detection and the severity of punishment discussed in Becker (1968) and Garoupa (1997) and (2001).

Expression (7) provides the third incentive compatibility constraint, which implies that the strategy *Enter cartel and Not Self-report* is preferred to not entering by both firms when $p \leq p^{**}(F, h_i)$, see also Figure 2 below. Secondly, recall the first incentive compatibility constraint, which implies that not self-reporting is preferred to self-reporting in the second stage if $p \leq p^*(F, h_i, \alpha)$. Combining these two constraints we obtain the following lemma.

Lemma 2 *For given policy parameters (F, f, p, α) , a subgame perfect equilibrium in which firms enter the cartel and do not self-report exists if $p \leq p^*(F, h_i, \alpha)$ and $p \leq p^{**}(F, h_i)$.*

The result of this lemma is quite intuitive. For low values of rate of law enforcement, the worst for society outcome may arise, i.e. firms collude and keep the cartel secret, even when leniency is introduced. However, looking at the right part of Figure 2, we conclude that for high values of α , when leniency programs are not too strict, the efficiency of antitrust enforcement can be improved more easily, since then a lower rate of law enforcement is necessary in order to obtain the second best outcome, namely, *Enter and Self-report*.

Finally, on the basis of Lemmas 1 and 2 we can conclude that the following proposition holds.

¹⁵See Appendix 1.

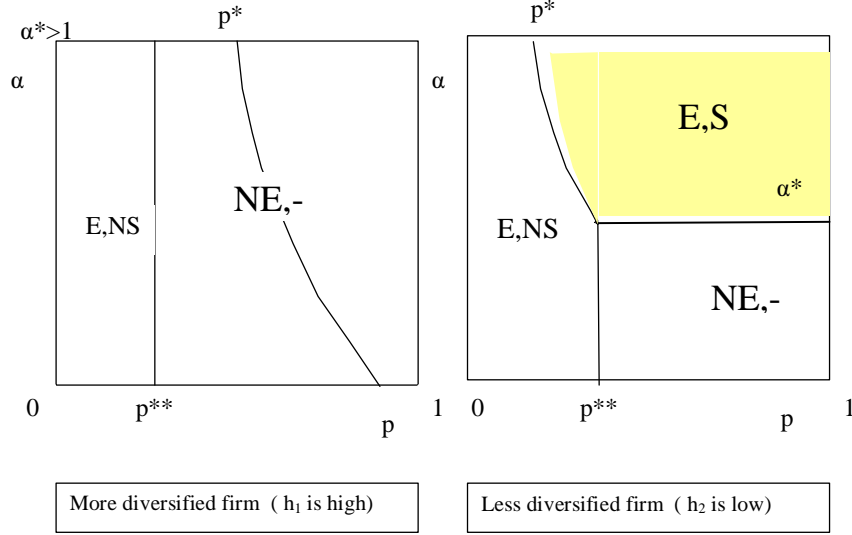


Figure 2: Incentive compatibility constraints for two types of firms.

Proposition 3 *Once the policy parameters (F, f, p, α) are set, in the repeated game played by the firms from $t = 1$ on, we can describe Subgame Perfect Equilibrium (SPE) in the (p, α) space as follows:*

1. *When $\alpha^*(h_i, F) \geq 1$ for $i = 1, 2$, i.e. when $(\pi_m - \pi_n) < Rh_i\delta$ for both firms, the Pareto dominant SPE is (Enter, Not Self-report) for $p \in [0, p^*(F, h_i))$, while the unique SPE is Not Enter otherwise.*
2. *When $0 \leq \alpha^*(h_i, F) < 1$ for $i = 1, 2$, i.e. when $Rh_i\delta + \frac{1}{2}F\delta > (\pi_m - \pi_n) > Rh_i\delta$ for both firms, the Pareto dominant SPE is (Enter, Self-report) for $p \in [p^*(F, h_i, \alpha), 1]$ and $\alpha \in [\alpha^*(F, h_i), 1]$, it is (Enter, Not Self-report) for $p \in [0, p^*(F, h_i))$ and $p < p^*(F, h_i, \alpha)$, while the unique SPE is Not Enter otherwise.*
3. *When $\alpha^*(h_i, F) < 0$ for $i = 1, 2$, i.e. when $(\pi_m - \pi_n) > Rh_i\delta + \frac{1}{2}F\delta$ for both firms, the Pareto dominant SPE is (Enter, Not Self-report) for $p \in [0, p^*(F, h_i, \alpha))$, while the unique SPE is (Enter, Self-report) otherwise.*

Proof: See Appendix 1.

This proposition identifies the regions where the (Enter, Self-report), (Enter, Not Self-report), and (Not Enter, -) equilibria exist. Clearly, both parameters p and α influence the choice of the non-collusive strategy. Moreover, any of the three possible outcome can arise in equilibrium only for intermediate range of profits, i.e. when $Rh_i\delta + \frac{1}{2}F\delta > (\pi_m - \pi_n) > Rh_i\delta$. For low gains from collusion, when $(\pi_m - \pi_n) < Rh_i\delta$, a SPE of the form (Enter, Self-report) does not exist.

While, when gains from collusion are high, $(\pi_m - \pi_n) > Rh_i\delta + \frac{1}{2}F\delta$, a pure competitive SPE does not exist.

5 Optimal Enforcement with Asymmetric Firms (Implementing the No Collusion Outcome)

This section provides an analysis of the enforcement strategies of an antitrust authority, which has the aim to prevent cartel formation in the industry. Here, we study the optimal enforcement policy in the game described in Section 6.4. The objective of antitrust authority is to maximize the discounted consumer surplus and the amount of collected fines minus the costs of control. The costs of control and amount of fines are completely determined by parameter p . Hence, the enforcement strategies are determined mainly through the rate of law enforcement, p . Further, we assume that the fine is fixed and equals its legal upper bound. However, in our setting there are two additional instruments that the antitrust authority can use to achieve the no-collusion outcome. One of them is leniency, i.e. the possibility of fine reduction if firms self-report; and the second is the strictness of leniency programs, or the possibility of getting complete exemption from the fine even in case simultaneous self-report occurs. As the amount of collected fines also depend on the strictness of leniency programs, the antitrust authority maximizes the following objective function: $W(p, \alpha) = \max_{p, \alpha} \{ \frac{CS}{1-\delta} - C(p) + p \sum f_i(\alpha) \}$.¹⁶ Here the aim of the authority is to maximize discounted stream of consumer benefits. Authority also wants to minimize the costs of control that are reflected in the term $C(p)$, which serves as a generalized notation for accumulated costs of audit, where discounting is already taken into account. Finally, we assume that the regulator's aim is to maximize the amount of fines. This is reflected in the term $p \sum f_i(\alpha)$, which serves as a generalized notation for expected accumulated collected fines.

The specific characteristic of our model is the fact that we consider asymmetric firms, in the sense that they are diversified to different extends. We point out the following regularities for the threshold probabilities which have been derived above. Assume $h_1 > h_2$, i.e. firm 1 is more diversified, then for the threshold probability determined in the "revelation subgame" the following inequality holds: $p^*(F, h_2, \alpha) < p^*(F, h_1, \alpha)$. However, for the threshold probability determined in the "cartel formation subgame" the opposite holds: $p^{**}(F, h_1) < p^{**}(F, h_2)$.

¹⁶We will also consider another form of objective function where the regulator is benevolent and does not have as a direct aim maximization of collected fines. In this case objective function of the authority is as follows: $W(p, \alpha) = \max_{p, \alpha} \{ \frac{CS}{1-\delta} - C(p) \} = \min_{\alpha} \{ C(p) \}$. This set-up gives similar but less general results.

Hence, it is more difficult to enforce self-reporting by bigger (more diversified) firms, but at the same time a smaller rate of law enforcement (less policing) is necessary in order to prevent the bigger firm from entering the cartel agreement in the first place.

First, we specify the enforcement technology and calculate welfare gains from implementing outcomes that are most desirable for society. These outcomes maximize the sum of consumer surplus and collected fines less the costs of control. We assume that imposing the monetary fines and determining the strictness of leniency programs is not costly, while increasing the probability of discovery involves costs. In general we expect a trade-off not only between the rate of law enforcement (policing) and the amount of imposed fines (fining), but also between the rate of law enforcement (policing) and the rules of leniency programs: increasing the strictness of leniency rules would imply a reduction in the level of policing required to reach a desired level of cartel formation and discovery. However, we will see that this intuitive trade-off does not always work in this direction.

In the further analysis deadweight losses will approximate losses of consumer surplus due to the fact that the market outcome does not coincide with competitive one. The traditional deadweight loss (DWL) measures the welfare gains associated with a successful intervention that induces a more competitive market equilibrium. We evaluate the welfare gains of antitrust enforcement by comparing the equilibrium outcomes (NE,-), (E,S), and (E,N) to the situation with collusion. Note that the antitrust authority will rank the regions as follows: (NE,-) gives higher welfare gains than (E,S); and (E,S) gives higher welfare gains than (E,N). Cartels entail an allocative efficiency loss, and, therefore, the antitrust authority aims to deter or break them if they are already formed. In the first case (NE,-), cartels are deterred; in the second case (E,S), cartels are broken in the second stage if they happen to be formed in the first stage; in the third case (E,N), only those cartels, which are investigated, will be broken.

5.1 Optimal Enforcement in the Two Stage Game

In this subsection we identify the optimal policies of the antitrust authority. Recall that the antitrust authority changes its policy throughout the planning horizon in the sense that leniency is introduced later in time than the penalty scheme. We first characterize the optimal policy when the antitrust authority wants to implement each of the three outcomes (NE,-), (E,S), or (E,N). Then we compare the implementable outcomes and select the best one.

As a general point in all the equilibrium outcomes, it is always optimal to set the fine equal to its legal upper bound since increasing the fines is not costly and allows to obtain more

favorable (lower) boundaries for the threshold probabilities for the rate of law enforcement.

In the model described above savings of dead weight loss $\frac{SDWL}{1-\delta}$ are the welfare gains from the (NE,-) equilibrium. The welfare gains, in case of the (E,S) equilibrium are $\frac{SDWL}{1-\delta} - SDWL = \frac{\delta SDWL}{(1-\delta)}$ ¹⁷. In the (E,N) equilibrium the antitrust authority interrupts collusion only with probability p , hence the welfare gains are $\frac{p\delta SDWL}{(1-\delta)}$. Note that the following inequality holds: $\frac{SDWL}{1-\delta} > \frac{\delta SDWL}{(1-\delta)} > \frac{p\delta SDWL}{(1-\delta)}$. Hence, the most favorable for society outcome is no cartel formation, second best is when firms collude and then reveal the cartel after leniency programs are introduced. The worst for society outcome is *Collude* and *Not Reveal*. Of course, this information is not enough for determination of the equilibrium that maximizes welfare, since costs of enforcement and revenues from collecting fines are not taken into account yet.

Figure 3 illustrates the optimal policies to implement each of the three outcomes discussed above. The solid lines p_1^* , p_1^{**} , and α_1^* represent the incentive compatibility constraints for the more diversified firm, while the dashed lines p_2^* , p_2^{**} , and α_2^* represent the incentive compatibility constraints for the less diversified firm. Moreover, in Proposition 4 we state the optimal policies that implement the (NE,-), (E,S), and (E,N) outcomes.

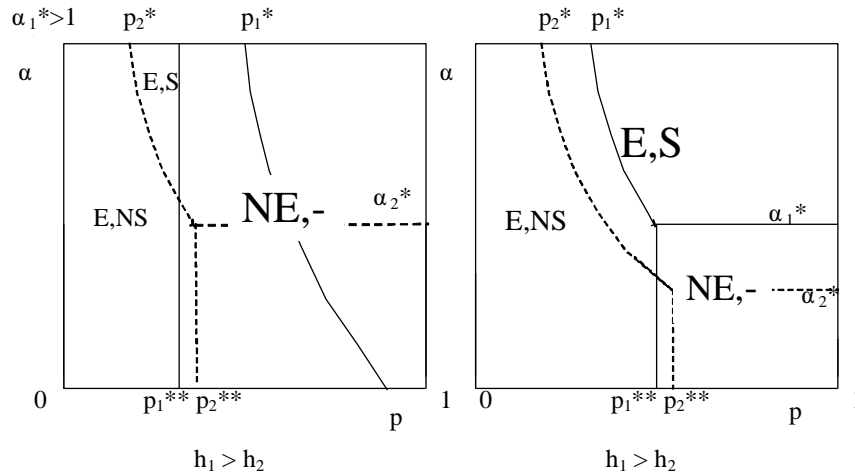


Figure 3: The optimal policies that implement the (NE,-), (E,S), and (E,N) outcomes. Solid lines represent incentive compatibility constraints for the more diversified firm and dashed lines represent incentive compatibility constraints for the less diversified firm.

Proposition 4 Let $h_1 > h_2$. Given the objective function of antitrust authority: $W(p, \alpha) =$

¹⁷Here we subtract the DWL in the first stage of the game, when the cartel is formed, from the total savings of DWL from period $t = 1$ till ∞ given by $\frac{SDWL}{1-\delta}$.

$\max_{p,\alpha} \{ \frac{SDWL}{1-\delta} - C(p) + p \sum f_i(\alpha) \}$, in the repeated game played by the firms from $t = 1$ on, the optimal policies are:

-implementing $(NE,-)$ sets $p = p_1^{**}$ and $\alpha \in [0, \alpha^*(F, h_1)]$.

-implementing (E,S) picks up the point that satisfies the equation $(p_2^*(\alpha))'_\alpha = -F$, if at this solution $p < p_1^{**}$. Otherwise, if $p > p_1^{**}$, then the optimal policy to implement (E,S) sets $p = p_2^*(1)$ and $\alpha = 1$ or $p = p_1^{**} - \varepsilon$ and $\alpha = \alpha^* + \varepsilon$.

-implementing (E,N) sets $p = 0$ and $\alpha \in [0, 1]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} + 2F < 0$, or $p = p_1^{**} - \varepsilon$ and $\alpha \in [0, \alpha^* - \varepsilon]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} + 2F \geq 0$.

Proof:

To simplify the calculations, throughout the proof of this proposition we assume that $C(p)$ is a linear increasing function of the following form $C(p) = \frac{p}{1-\delta}$. Clearly, this implies per period costs of control will be equal to p . However, qualitative results would not change, if we assume any increasing and convex functional form.

1. The proof of the first part of the proposition follows directly from Figure 3. The social welfare in case cartel formation does not occur is given by $W_{(NE,-)}(p, \alpha) = \frac{SDWL}{(1-\delta)} - p + 0$. It does not depend on α . Hence, the optimal policy to implement $(NE,-)$ would just minimize p and, hence, sets $p = p_1^{**}$ and $\alpha \in [0, \alpha_1^*]$.

2. The proof of the second part of this proposition is based on the idea that the solution of the maximization problem:

$\{ \max_{p,\alpha} \{ \frac{\delta SDWL}{1-\delta} - p + (1-\alpha)F \} \text{ s.t. } V_{E,S} > V_{NE,-} \text{ and } V_{E,S} > V_{E,NS} \}$ is given by the tangency point of the iso-welfare curve in case the (E,S) outcome is implemented with the lowest incentive compatibility constraint for self-reporting to be profitable, i.e. $p_2^*(\alpha)$.

In this situation two cases can arise:

Firstly, if at the tangency point $p < p_1^{**}$, the welfare, in case the (E,S) outcome is implemented, is given by $W_{(E,S)}(p, \alpha) = \frac{\delta SDWL}{(1-\delta)} - p + (1-\alpha)F$. Hence, the slope of the iso-welfare curve will be equal to $-\frac{\partial W_{(E,S)}(p,\alpha)/\partial \alpha}{\partial W_{(E,S)}(p,\alpha)/\partial p} = -F$, implying that the tangency point is determined by the solution of the following equation: $(p_2^*(\alpha))'_\alpha = -F$. See point A in Figure 4, where the dashed negatively sloped straight lines represent iso-welfare curves.

Secondly, if at the tangency point $p > p_1^{**}$, we consider two corner solutions.

The first is given by $p = p_2^*(1)$ and $\alpha = 1$. This is illustrated by point B in Figure 4 below. The welfare in this case is given by $W_{(E,S)}(p_2^*(1), 1) = \frac{\delta SDWL}{(1-\delta)} - p_2^*(1) + 0$

The second is given by $p = p_1^{**} - \varepsilon$ and $\alpha = \alpha^* + \varepsilon$, where $\alpha^* : p_2^* = p_1^{**}$. This is

illustrated by point C in Figure 4. The welfare in this case is given by $W_{(E,S)}(p_1^{**}, \alpha^* + \varepsilon) = \frac{\delta SDWL}{(1-\delta)} - (p_1^{**} - \varepsilon) + (1 - (\alpha^* + \varepsilon))F$

3. The third part of the proposition follows directly from Figure 3 and the objective function of the antitrust authority: $W_{(E,N)}(p, \alpha) = \max_{p, \alpha} \{ \frac{p\delta SDWL}{(1-\delta)} - \frac{p}{1-\delta} + p2F \}$.

Then there are only corner solutions given by $p = 0$ and $\alpha \in [0, 1]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} + 2F < 0$; and by $p = p_1^{**} - \varepsilon$ and $\alpha \in [0, \alpha^* - \varepsilon]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} + 2F \geq 0$. So, if gains to the society from conviction are low, it is reasonable not to control at all. And vice versa, if gains due to the savings of DWL and fines that can be collected are high, it is desirable for the antitrust authority to impose a strictly positive rate of law enforcement, $p = p_1^{**} - \varepsilon$.

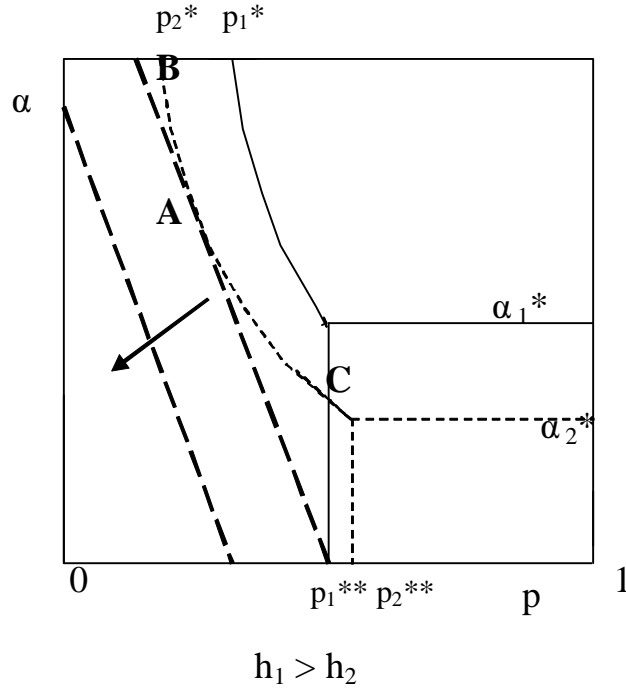


Figure 4: Implementation of (E,S) outcome.

End of the proof.

We can conclude that the first best outcome, i.e. when the cartel is not formed, can be achieved only with a sufficiently high rate of law enforcement, i.e. $p \geq p_1^{**}$, and when the rules of leniency programs are strict enough, $\alpha < \alpha^*(F, h_1)$ (in other words, in case of simultaneous self-reporting both firms almost certainly get no exemption from the fine). However, if the cartel has already been formed in the first stage, before the leniency program was introduced, the optimal policy that can ensure the second best outcome, i.e. self-reporting in the second

stage, should impose a lower rate of law enforcement, $p_2^*(1)$, and less strict rules of leniency programs, $\alpha = 1$. Hence, in general the enforcement that aims at stopping formation of already existing cartels should be less strict.

In the next proposition we state a similar result for the less general case, where the objective function of the antitrust authority is given by $W(p, \alpha) = \max_{p, \alpha} \left\{ \frac{SDWL}{1-\delta} - C(p(\alpha)) \right\} = \min_{p, \alpha} \{C(p(\alpha))\}$. However, it must be noted that the former case is more relevant for the current objectives of antitrust enforcement, since in most cases the authority takes into account the objective of maximizing the amount of fines collected. While, the ideal benevolent antitrust authority takes into account only the objective of minimizing dead weight loss and reducing the costs of law enforcement. In this case the following proposition holds.

Proposition 5 *Let $h_1 > h_2$ and the objective function of the antitrust authority is given by $W(p, \alpha) = \max_{p, \alpha} \left\{ \frac{SDWL}{1-\delta} - C(p(\alpha)) \right\} = \min_{p, \alpha} \{C(p(\alpha))\}$*

in the repeated game played by the firms the optimal policies of antitrust authority that implement the $(NE, -)$, (E, S) , and (E, N) outcomes are:

- The optimal policy to implement $(NE, -)$ sets $p = p_1^{**}$ and $\alpha \in [0, \alpha^*(F, h_1))$.
- The optimal policy to implement (E, S) sets $p = p_2^*(1)$ and $\alpha = 1$.
- The optimal policy to implement (E, N) sets $p = 0$ and $\alpha \in [0, 1]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} < 0$, or $p = p_1^{**} - \varepsilon$ and $\alpha \in [0, \alpha^* - \varepsilon]$ if $\frac{\delta SDWL}{(1-\delta)} - \frac{1}{1-\delta} \geq 0$.

Proof: See Appendix 2.

We conclude that under a different objective function still the result is qualitatively the same. An interesting implication of this analysis is that the regulation by a benevolent authority would not only lead to lower fines for firms and less strict leniency programs, but will also reduce the costs of law enforcement in some scenarios.

6 Conclusions

This paper studies the effects of antitrust enforcement and leniency programs on the behavior of firms participating in cartel agreements. The main innovation of our analysis, compared to the earlier papers on leniency by Motta and Polo (1999) and (2003) or Feess and Walzl (2003), is that we consider asymmetries between firms. In general, firms have different size and operate in several different markets. However, they form a cartel in one market only. This gives rise to additional costs in case of disclosure of cartel caused by a reduction of sales in other markets

due to a negative reputation effect. This effect is asymmetric for firms that are diversified to different extents, that is the smaller the percentage of turnover in markets covered by the cartel in relation to total turnover of a firm. The same modelling framework can be applied to the case of international cartels, where firms that form a cartel come from different countries and, consequently, will be subject to different punishment procedures. The most striking example of this asymmetry concerns international cartels of European and US firms. In this situation, due to the fact that in US consumers engage in private law suits more often than in Europe, the actual penalty for the US firm would be greater than for the European firm in case the cartel is discovered and information about its existence becomes public. Hence, following the terminology introduced in this paper, US firms will correspond to more diversified firms, or the firms that suffer higher costs other than fines in case of disclosure of cartel.

In the paper we study the situation where the antitrust authority changes its policy throughout the planning horizon in the sense that leniency is introduced later in time and not simultaneously with the penalty scheme¹⁸. This reflects the situation, for example, in The Netherlands before and after the year 2001, when the leniency programs were introduced in Dutch Competition Law. This model can also be used for analyzing the economic implications of the introduction of leniency programs in countries, where these programs have not yet been introduced, such as developing or countries in transition.

Another feature of our approach is that the enforcement strategies of antitrust authority are determined not only through the rate of law enforcement, but also through an additional instrument (called "strictness" of leniency programs), i.e. introducing the possibility of getting complete exemption from the fine even in case many firms self-report simultaneously. We study the impact of the "strictness" of leniency programs on the effectiveness of antitrust enforcement and derive the optimal enforcement strategies.

First, we describe the general results, which come from the analysis of the behavior of asymmetric firms. We found that the bigger the size of the firm (or the more the firm is diversified), the higher the incentives for this firm to keep the cartel secret. Then greater efforts from the antitrust authority, in terms of increasing the rate of law enforcement, are needed in order to induce self-reporting by this firm. So, leniency programs work better for small (less diversified) companies in the sense that they result in self-reporting by small firms while the

¹⁸The same framework can be applied to study the effects of leniency programs on the behavior of firms participating in cartel agreements in case, where the structure of the penalty schemes and leniency programs are introduced at the beginning of the game. For more details see subsection on timing of the game.

rate of law enforcement is lower, which implies lower costs for society.

Furthermore, we can conclude that for bigger firms the strategy of not entering the cartel agreement in the first stage of the game is more likely to be preferred over the strategy to form a cartel and then self-report, than for smaller (less diversified) firms. The bigger the size of the firm (or the higher its losses due to the reputation effect), the easier it is for the antitrust authority to prevent the firm from entering the cartel agreement in the first stage of the game. Hence, big firms (or firms for which costs other than fines are higher) are more reluctant to start a cartel in the first place.

Next, we proceed by describing the optimal combination of instruments of antitrust authority: rate of law enforcement and "strictness" of leniency programs. Uncertainty of the firms about getting the first prize (or, in other words, strictness of the rules for leniency, which can grant the complete exemption from the fine only to one firm) reduces the incentives for both types of firms to self-report. Therefore, in a highly cartelized economy, where a lot of cartels are already formed, the best strategy for the antitrust authority is to concentrate on policies that increase the incentives to self-report, in particular, increase the fine or reduce the strictness of leniency programs. In other words, the more cartelized the economy, the less strict the rules of leniency programs should be, or in other words, complete exemption from fine should be granted to all self-reporters.

On the other hand, when there are not too many cartels and leniency is not yet introduced, the antitrust authority should implement the policy that reduces the incentives to enter the cartel agreements in the first place. In this case both, the fine and the strictness of the leniency programs, should be increased. Hence, when the economy is not highly cartelized the rules of leniency programs should be more strict, i.e. complete leniency should be granted only to the first self-reporting firm.

Finally, we conclude that the optimal enforcement can implement the no collusion outcome only when the rate of law enforcement is sufficiently high and the rules of leniency programs are sufficiently strict. Moreover, the second best outcome, i.e. (*Enter cartel and Self-report*), can be implemented when the rate of law enforcement is sufficiently high and the leniency programs grant complete exemption from fines to all the firms that cooperate with antitrust authority.

To conclude the discussion, it is worthwhile to mention that the framework developed in this paper can also be used for an analysis of the effectiveness of leniency programs in situations where disclosure of cartel can lead to additional costs for the firms different from the fine for violations of competition law itself. Those costs can result from the threat that tax authorities

will conduct additional control and possibly frauds connected with cartel agreements will be discovered, or consumers will challenge firms in the courts applying for private law damages. Obviously, the threat of all these additional losses would reduce incentives for the firms to self-report and diminish the effectiveness of leniency programs for already existing cartels. However, the positive feature is that at the same time this would also reduce the incentives for the firms to enter new cartel agreements.

7 Appendix

7.1 Appendix 1: Proof of Proposition 3

The result of this proposition follows directly from Lemmas 1 and 2 and the fact that all three locuses $p^*(F, h_i, \alpha)$, $p^{**}(F, h_i)$, and $a^*(F, h_i)$ intersect in the same point. Simple algebraic calculations confirm that $p^*(F, h_i, \alpha^*) = p^{**}(F, h_i)$.

In order to prove this fact we substitute $\alpha^*(h_i, F) = \frac{2Rh_i\delta + F\delta - 2(\pi_m - \pi_n)}{\delta F}$ into the expression for p^* in (2) and show that $p^*(F, h_i, \alpha^*) = p^{**}(F, h_i)$.

$$\text{Recall that } p^*(F, h_i, \alpha) = \frac{\pi_m - \pi_n + Rh_i(1-\delta) + \frac{(1-\delta)(1-\alpha)}{2} F}{\pi_m - \pi_n + Rh_i(1-\delta) + (1 - \frac{\delta(1-\alpha)}{2}) F}.$$

$$\text{Hence, } p^*(F, h_i, \alpha^*) = \frac{\pi_m - \pi_n + Rh_i(1-\delta) + \frac{(1-\delta)(1 - \frac{2Rh_i\delta + F\delta - 2(\pi_m - \pi_n)}{\delta F})}{2} F}{\pi_m - \pi_n + Rh_i(1-\delta) + (1 - \frac{\delta(1 - \frac{2Rh_i\delta + F\delta - 2(\pi_m - \pi_n)}{\delta F})}{2}) F} = \frac{\pi_m - \pi_n}{\delta(F + Rh_i)} = p^{**}(F, h_i).$$

End of the proof.

7.2 Appendix 2: Proof of Proposition 5

Again, in order to simplify the calculations, throughout the proof of this proposition we assume that $C(p)$ is a linear increasing function of the following form $C(p) = \frac{p}{1-\delta}$. Clearly, this implies per period costs of control will be equal to p . However, qualitative results would not change, if we assume any increasing and convex functional form.

1. The proof of the first part of proposition follows straightforwardly from Figure 4.
2. The second part of the proposition says that a combination of policy instruments of the form $p = p_2^*(1)$ and $\alpha = 1$ would minimize the costs of law enforcement in case the (E,S) outcome has to be implemented and, hence, it would maximize the social welfare $W(p, \alpha) = \frac{\delta DWL}{1-\delta} - p(\alpha)$.

Indeed, recall expression (3), which says that $\frac{\partial p^*(F, h_i, \alpha)}{\partial \alpha} < 0$. This implies that $\min_{\alpha} p^*(\alpha) = p^*(1)$. Now looking at Figure 4, we conclude that optimal policy to implement (E,S) sets $\alpha = 1$ and $p = \min_{\alpha} p^*(\alpha) = p_2^*(1)$.

3. Finally, the third part of proposition follows directly from Figure 4 and from the objective

function of antitrust authority $W(p, \alpha) = \max_p p(\frac{\delta DWL - 1}{1 - \delta})$. This implies that $p = 0$ and $\alpha \in [0, 1]$ if $\frac{\delta DWL}{1 - \delta} - \frac{1}{1 - \delta} < 0$, or $p = p_1^{**} - \varepsilon$ and $\alpha \in [0, \alpha^* - \varepsilon]$ if $\frac{\delta DWL}{(1 - \delta)} - \frac{1}{1 - \delta} \geq 0$.

End of the proof.

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